# MUSK OX WOOL AND ITS POSSIBILITIES AS A NEW TEXTILE FIBER.

by

Werner Von Bergen

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# Musk-Ox Wool and Its Possibilities As a New Textile Fiber

*By* WERNER VON BERGEN*

The search for new fiber sources and the improving of the fibers already on the market is occupying the entire time of thousands whose discoveries are quickly appreciated by millions. Especially in the field of synthetic fibers such as the various forms of rayon, these researches brought wonderful results. This progress caused the manufacturers of natural fibers to awake from their dormant state to start an extensive research if only for self-preservation. After the World War, the efforts to lift the whole textile industry out of grandfather's time increased rapidly. Today's business depression demands the best that one has in him to overcome the crisis.

In the kingdom of wool and related fibers, we have met some strangers. The last few years have seen the rise in popularity of the very finest materials, such as cashmere, camel hair, rabbit hair, and soft, shiny, coarse hairs, such as alpaca, mohair, and llama. By blending these different materials with wool, silk, and others, wonderful new effects were secured which found an enthusiastic reception.

## Mohair

It is logical that due to the greater demand for these fibers, the output of raw material by the breeder should have been increased. Accurate statistics are available covering only mohair. The following figures show this to be true in the case of mohair.

| Year | U.S.A. | Turkey | Cape Colony | Total |
|---|---|---|---|---|
| 1900 | 961,000 lbs. | ..... lbs. | ..... lbs. | 961,000 lbs. |
| 1902 | 1,250,000 " | 8,500,000 " | 7,500,000 " | 17,250,000 " |
| 1914 | 4,500,000 " | ..... " | ..... " | 4,500,000 " |
| 1918 | 6,000,000 " | ..... " | ..... " | 6,000,000 " |
| 1928 | 14,522,000 " | 10,950,000 " | 7,550,000 " | 33,022,000 " |

The world production has gained 91% within a period of 26 years. The main reason is to be found in the tremendous increase in the breeding of the mohair goats in the United States which rose during the same period over 1,000%. In consequence, the participation of the United States in the world production climbed from 7% to 44%. This truly is a fine example in a particular instance which proves what can be achieved by a well planned and continued effort; not mentioning the benefits derived by those directly connected with it, but also the economic gain for the whole country.

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## Alpaca

Another estimate of the world production of a lated fiber is possible only in the case of alpaca. figures were obtained from the principal trading p —Liverpool.

| AVERAGE | 1919-1920 | 1927-1928 |
|---|---|---|
| | 3,900,000 lbs. | 5,700,000 lbs. |

The world production of camel hair and cashm can hardly be estimated for the reason that the p ducing countries like China and Russia do not furn reliable statistics and whatever is shipped out is tributed to many countries and through many pc There must be over a million camels in China Russia, producing about 8,000,000 lbs. of wool, which amount more than one-half is exported. raising of these animals has not been developed o large scale but is carried on in a haphazard way nomadic people who can take care only of small nu bers of animals and for whom the use of the ani for draft or burden or dairy needs is more import than the production of hair. Another big factor the transportation difficulties and, besides that, po cal conditions are unsettled.

## Breeding Foreign Animals

According to the "Census of Manufacturers," 1 (Wool Manufacturers) by the Department of C merce, the importation of alpaca, camel hair, amounted to 6,620,000 lbs. which at that time rep sented a value of about $1,751,000. Not a sin pound of these fibers is produced in this country, we are wholly dependent on the irregular foreign s ply. This brings up the question if we should consider the desirability and possibility of creatin supply within our own country. There are cer definite climatic and food conditions to which es cially alpaca and llamas are accustomed and which not exist in our country. The breeding of car could receive consideration only if full use could made of them as a domesticated animal, especially a beast of burden, which is not possible in the land the automobile. Similar reasons exist why the bre ing of the cashmere goat is hardly feasible in country. From these facts we see that the possib of success in breeding foreign animals is very rem

## Musk-Ox

is to the credit of the famous arctic explorer Vil-
hur Stefansson who called attention to the musk-
f Canada and Greenland, an animal which is
tened with extinction, although of the greatest
rtance for the arctic countries. These animals
ice one of the finest wools, if not the finest in the
e world.

e Canadian Government for the past several
has been making vigorous efforts to preserve the
ant of these interesting animals, having estab-
l several game reservations for them, one of the
important of which is the Thelon sanctuary, east
reat Slave Lake in Northwest Territories. Here
250 musk-oxen still exist where adequate range
been set aside for them, and the most effective
ction possible is being afforded in the hope that
may not only maintain themselves but also in-
e materially in numbers.

ese efforts of the Canadian Government for the
rvation of the musk-ox have received wide atten-
n our country, as Alaska was formerly a habitat
eirs. The result of this was that in 1927 the
lature of the Territory of Alaska decided to
orialize Congress to acquire a herd of musk-oxen
ntroduction into Alaska for experimental pur-
with a view to their domestication and utiliza-
n this territory. Under the energetic leadership
epresentative L. J. Dickenson of Iowa and Sen-
Peter Norbeck of South Dakota, Congress in
appropriated $40,000 to provide for the estab-
g of an experimental herd of musk-oven at the
leer Experiment Station near Fairbanks, Alaska.
der the supervision of the Biological Survey of
the Department of Agriculture during the summer of 1930, 34 heads of musk-oxen were brought to New York and then shipped via Seattle to Fairbanks, Alaska. There they are kept in a large inclosure under the care of men from the experimental station of Fairbanks College, Alaska.

It is the hope of all concerned that these rare animals may be successfully domesticated and their numbers increased to utilize part of the vast food resources of Alaska that are now largely wasted, and to afford a stable source of meat as well as valuable robes and other products.

Before we go into detail about the musk-ox wool, and its value to the textile industry we would like to know a little more about the animal itself.

*Courtesy N. Y. Zoological Society*

Fig. 1. Musk-Ox

*Origin.*

Musk-oxen are the most truly arctic of all the large mammals occurring in North America. At the time of the earliest exploration they inhabited the vast territory north of the great transcontinental forest, roaming from the northwestern shores of Hudson Bay to the Mackenzie River and over most of the arctic islands and northern Greenland. They formerly existed in some numbers in northern Alaska. Fortunately they have persisted to the present time in limited numbers in northern Canada, eastern Greenland and some of the arctic islands, though they are much reduced from their former numbers.

In appearance musk-oxen resemble somewhat a small-sized buffalo or bison (see Figure 1), to which they are probably more nearly akin than to any other American animal. There is a distinct hump on their shoulders, though it is not so conspicuously developed

as in the bison, and the head is carried high when the animal is on the alert. Their general color is a dark brownish black with a lighter brown or cream color on the back, and the legs are much lighter colored. In animals of the more northern herds there is a lighter area on the forehead. The tail is short and does not extend beyond the hair on the rump. There is an undercoat of thick wool through which grows a protective coat of long black guard hairs that may sweep almost to the ground and that gives the animal a low stocky appearance. Both sexes of the musk-ox have horns. The average weight of the animal is 400 lbs., the largest male up to 600 lbs. The bull varies from six to eight feet in length of body and its height is from four to five feet at the shoulders.

*Life of the Musk-Ox.*

The musk-ox is usually seen in herds numbering from a dozen or so to eighty or a hundred head. In Autumn the herds are largest. They have a special method of combining for defense; they round up in the middle of a plain, with tails together and heads toward the enemy. This system of defense proved exceedingly effective against all natural enemies such as the wolves, but left them hopelessly powerless against the attacks of men armed with firearms. Hunters are thus enabled to shoot down an entire herd, which because of the animals' gregarious habits may represent all the musk-oxen within many miles, a fact that accounts in part for the rapidity of their extermination from much of their range, after improved firearms were employed in their pursuit.

The total number of musk-oxen alive today can only be estimated. R. M. Anderson, chief of the Division of Biology, National Museum of Canada, estimates about 13,000 musk-oxen remaining on Canadian territory and approximately 1,500 animals in Greenland, so we have from fourteen to fifteen thousand animals alive today, which gives approximately one per cent of the original estimated stock of somewhat less than a million in 1800.

## Physical Properties of the Hair Coat

Through the courtesy of Dr. W. Reid Blair, Director of the New York Zoological Garden, and L. J. Palmer, Senior Biologist, Fairbanks College, Fairbanks, Alaska, I secured different samples of musk-ox hair which enable me to give you the following data: There are four known species of the animal. In our case the samples are taken from the *White Faced Musk-Ox*—Ovibus moschatus wardi. Main characteristics: White space between horns and on face, also generally whitish on sides of head, more white on feet. General color—dark grey; homeland —eastern Greenland. As already mentioned the consists of an outer covering of coarse brown or beard hair which curls and is matted on the back elsewhere is very long and conceals the upper ha the legs. Next to the skin is a growth of fine grey wool (down) so dense as to be impervio moisture. The wool hair is very soft and has a gloss. It is whitish grey towards the skin and cha to a grey. The point of change is very sharp. length of the white zone varies from one sixteent an inch to over one inch, depending on the place w the hair grew. Some samples from the New Y Zoological Garden didn't show any white zone at No regular staples are formed since the down gr nearly evenly over the whole skin. On some pla especially on the back part the wool hairs have tendency to grow into beard hair. The lower par such hairs is very curly, however the upper par wavy like the regular beard hair. The beard hairs brown or black mixed with a few white ones, percentage of beard and wool hairs in the differ samples and their length is seen from Table I.

TABLE I

1. Length of Hair Sample, New York, 1930. Age of mal—1 yr.

| Wool Hair | | Beard H |
|---|---|---|
| Variation | ½–6″ | Variation 1– |
| Under 2″ | 3% | Under 4″ 3 |
| From 2–5″ | 89% | From 4–8″ 6 |
| Over 5″ | 8% | Over 8″ 1 |

2. Length of Staples Samples, New York, 1931. Age animal—2 yrs.

| | Male | | Female | |
|---|---|---|---|---|
| | Shoulder | Back | Shoulder | Back |
| Wool Hair | 1¼–1½″ | 1¼–1⅜″ | 1½″ | 1¼–1⅜″ |
| Beard Hair | 4 –7 ″ | 2½–4″ | 3½–4″ | 2½–3½″ |

3. Length of Staples Samples, Alaska, 1931. Age abo 9 months.

| | Male | | Female | |
|---|---|---|---|---|
| | Shoulder | Back | Shoulder | Ba |
| Wool Hair | 2¼–2½″ | 2–3″ | 2½–3½″ | 2½ |
| Beard Hair | 3–4 ″ | 3½″ | 3 –4 ″ | 3½ |

4. Percentage of Wool and Beardhair. Samples, New Yor 1931.

| | Male | | Female | |
|---|---|---|---|---|
| | Shoulder | Back | Shoulder | Bac |
| Wool Hair | 60% | 70% | 85% | 80% |
| Beard Hair | 40% | 30% | 15% | 20% |

5. Percentage of Wool and Beardhair. Samples, Alaska 1931.

| | Male | | Female | |
|---|---|---|---|---|
| | Shoulder | Back | Shoulder | Bac |
| Wool Hair | 95% | 60% | 95% | 60% |
| Beard Hair | 5% | 40% | 5% | 40% |

## Microscopical Examination

*Hair.*

hair, like the merino wool fiber, consists of the mis and the cortical layer. Medullae are very n found. The scales are clearly visible especially of the light fibers. (See Figure 2.) The num-

Fig. 2. Musk-Ox Wool (240 X)

of scales per 100 microns (0.1 mm or 1/250 inch) between four and nine, the average being six. ee Figure 6.) In the dark hairs, the cortical layer is covered with grey-black dyestuff pigments mostly in patches. The hair taken from the animal during the shedding time shows the root end as well as the fine tapering end. (See Figure 3.)

Root Hair Body End

Fig. 3. Musk-Ox Wool (240 X)

*Fineness.*

As it is impossible from such small samples, which I have from a few animals, to get an accurate aver-

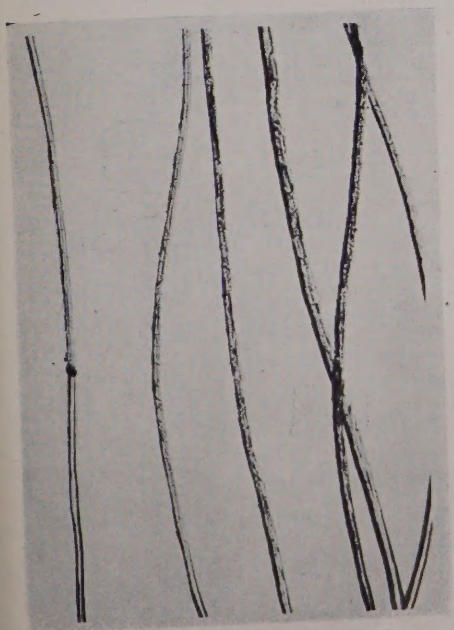


Fig. 4. Musk-Ox Wool (120 X.) Near the skin

Fig. 5. Musk-Ox Wool (120 X.) Middle part gray

age sample, the fibers were measured (with a few exceptions) on the root end, that means, about a half a centimeter above the skin. This method, although the best from a scientific standpoint and more and more used by the sheep breeder, cannot be us half-manufactured, or finished goods, as it is i sible, from the scoured wool on, to find the root

The fineness found after this method is alwa or two microns too high, as all the fibers are finer at the root end than in the middle or uppe of the staple. This is best explained by the foll examples, and it can be seen from Figures 4 an

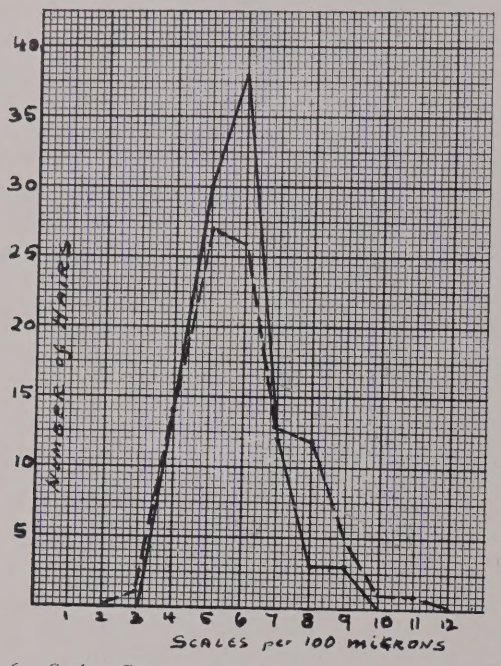



Fig. 6. Scales Curves Musk-Ox Woolhair Scales per 100 microns.———New York
— — — Alaska

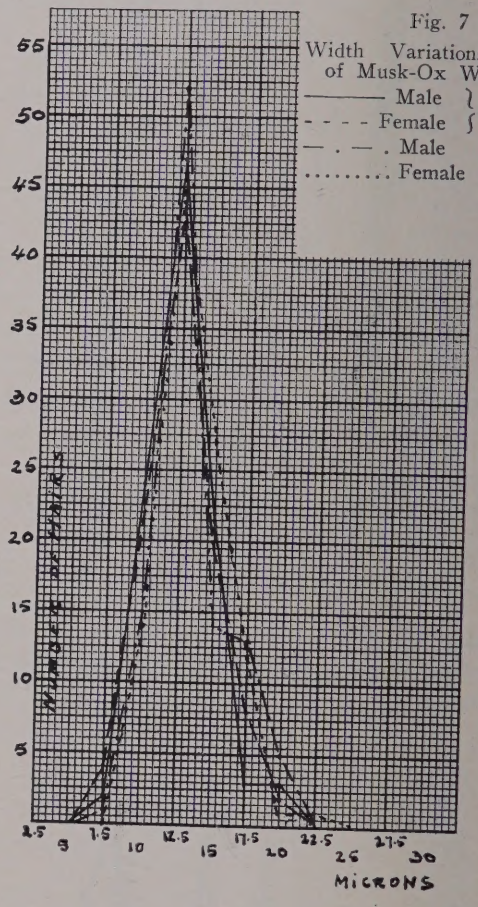



Fig. 7
Width Variations (
of Musk-Ox Woolh
——— Male ) Al
- - - - Female ) 1
— . — . Male ) 1
..... Female ) 1

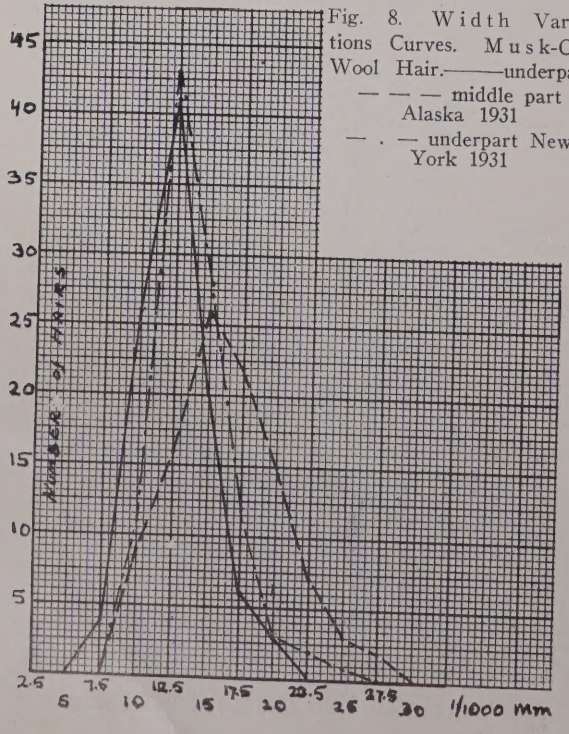



Fig. 8. Width Variations Curves. Musk-Ox Wool Hair.———underpart
— — — middle part Alaska 1931
— . — underpart New York 1931

| | Musk-Ox Wool | | | Austra n |
|---|---|---|---|---|
| | Shoulder | Back | Cashmere | Meri |
| Root End ..... | 11.55$\mu$* | 11.25$\mu$ | 14.25$\mu$ | 15. $\mu$ |
| Middle Part.... | 13.65$\mu$ | 15.77$\mu$ | 16.63$\mu$ | 18. $\mu$ |

*1$\mu$ or micron equals 0.001 millimeter or 1/25400 of an i

The width of the musk-ox wool hair was fou to be extremely regular and extremely fine. The v ues are given in Figures 7 and 8.

*Measurement of the Fineness.*

| Number of Hairs | | Sample Alaska Feb. 1931 Average Width Root End | Middle Part | Sample New Yo June 1931 Average Wi Root End |
|---|---|---|---|---|
| 100 | 6$\mu$—30$\mu$ | 11.55$\mu$ | 13.65$\mu$ | 13.00$\mu$ |
| 300 | | 11.36$\mu$ | 15.40$\mu$ | 12.78$\mu$ |
| 500 | | 11.43$\mu$ | 15.28$\mu$ | 12.78$\mu$ |

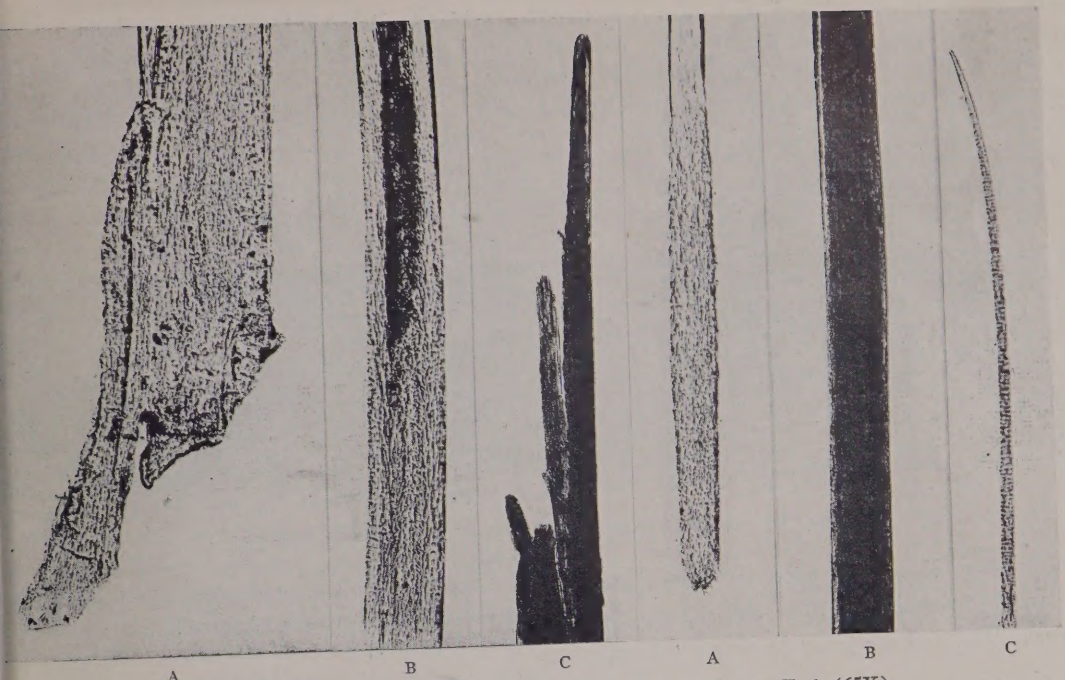



Fig. 10. Musk-Ox Beardhair. A. Root. B. Hairbody. C. End (65X)

s an interesting fact that the hairs grown in York are all one micron coarser. This difference e caused by the climatic conditions. In this con- n, we have a similar thing in the length of the s, see Table I, from which we see that the

| | Sample Alaska | | Sample New York 1931 | |
|---|---|---|---|---|
| | Male | Female | Male | Female |
| Shoulder | 11.50$\mu$ | 11.43$\mu$ | 12.20$\mu$ | 12.85$\mu$ |
| Back | 11.55$\mu$ | 11.25$\mu$ | 12.95$\mu$ | 13.05$\mu$ |

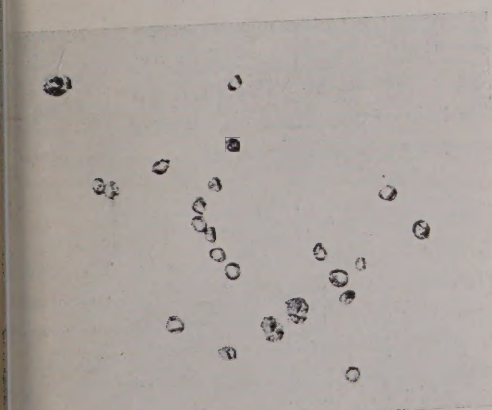


Fig. 9. Cross-sections Musk-Ox Wool (120X)

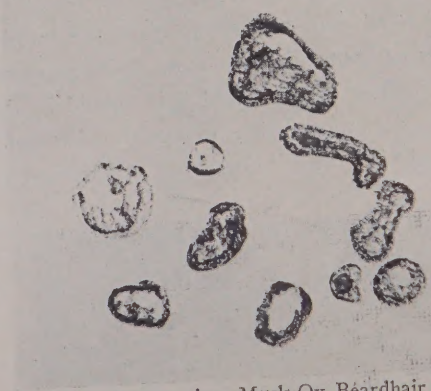


Fig. 12. Cross-sections Musk-Ox Beardhair (120X)

York wool is much shorter, although it is one 's growth compared with nine months growth of Alaska wool. In the much warmer New York ate, the animals do not need such a heavy down, nature automatically takes care of the change in litions. No difference was found between the ness of the wool grown on the male and female, between the hairs from the shoulders and back he animals.

The cross section of the fiber is practically circular, as can be seen in Figure 9, and, therefore, the direct measuring of the width is accurate enough.

*Beard Hairs.*

The beard hair consists of three parts, the epidermis, the cortical layer, and the medulla. The medulla constitutes on the whole the larger part of the hair. The root and the extreme end do not contain any

medulla. Partially medullated hair rarely is found. Figure 10 illustrates two beard hairs with roots and ends. Many ends of the beard hairs are split in two or three parts similar to those seen in Figure 10.

*Fineness.*

The width of the beard hairs is extremely irregular, they vary from 25 to 225 microns. The following values were determined from 300 hairs, Sample New York 1930, and are given in diagram Figure 11.

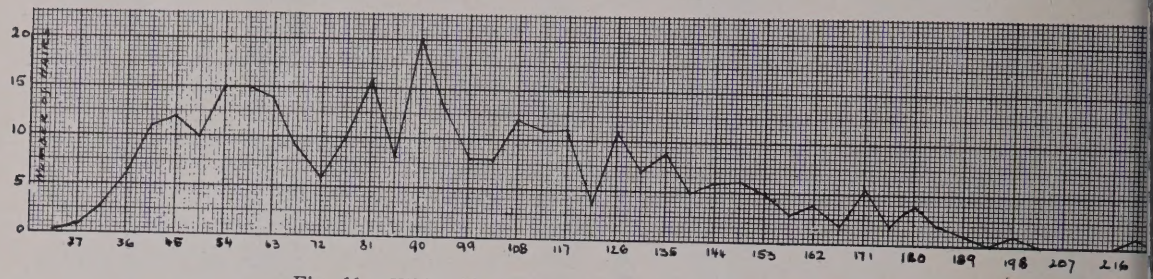



Fig. 11. Width Variations Curve of 300 Musk-Ox Beardhairs

| Number of Hairs | Average Diameter |
|---|---|
| 100 | 104.1$\mu$ |
| 200 | 100.4$\mu$ |
| 300 | 94.9$\mu$ |

The cross-sections of beard hairs vary in form, from sections with very flattened sides to those which are circular. (See Figure 12.) Some of the sections show in the medulla empty spaces which are caused by the spongy cell-like nature of the medulla. These spaces are filled with air, which gives the uncolored beard hairs or kemp fiber its snow white appearance. The true fineness of the beard hair should be determined from the cross-section on account of the elliptical and band-like forms. For practical purposes, however, the ordinary microscopical method of me the width is sufficiently accurate.

## Chemical Nature and Properties

The raw musk-ox hair contains about 8% the possible yield in the clean material, judged f few samples which I had, will be around 80%.

The affinity to wool dyestuffs is equal to any wool. The brightness of the shades is limited b of the natural gray of the wool. Through blea this natural color can be lightened to a very ligh but not entirely removed. The fiber is more ser to chemicals, alkalies and acids than wool due t high fineness.

## Differentiation Between Related Hai

As the animal is a species which has no direct tion to any of the wool bearing animals, we are able to decide to which technical hair it comes ne by studying the microscopic structure of the Deputy Minister Cory of the Northwest Territ Canada, wrote me the following:

"The hair of the Musk-Ox is similar to that o Thibetan Yak, possibly coarser."

## Thibetan Yak

The wild and domesticated ox (Bos Grunniens o the Thibetan plateau is known by this name and species nearly allied to the bison group. The wild generally black, is found near the snowline. h domesticated species, usually half-breeds, is of var colors, black and white being most common. The is about the size of a common ox, but is covered th a thick coat of long hair, hanging down like the fl

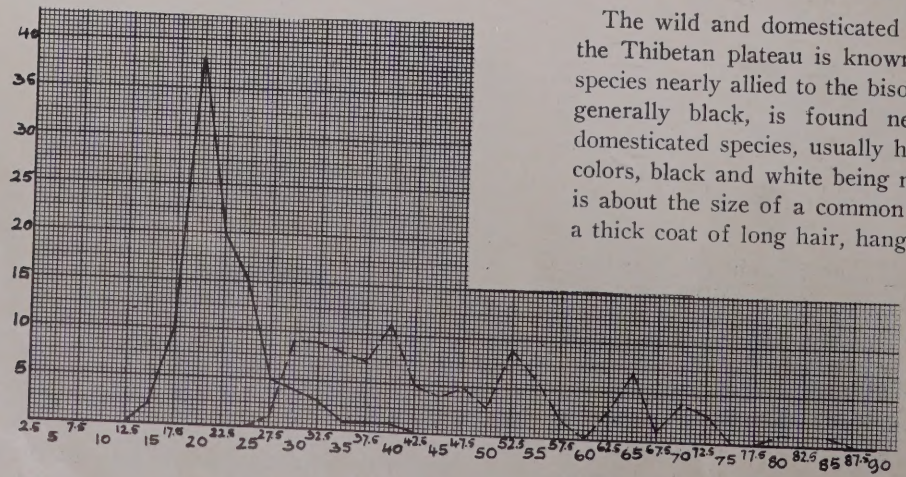



Fig. 13
Width Variation
Curves of
Yak Hair

goat, completely investing the tail and forming a hy fringe along the shoulders, flanks and thighs. fringe which exists in both species was apparently loped as a protection for the animal in its Alpine ts, as the long hair forms a sort of mat, which de- s the body from the effects of the cold, when the al is reposing in the snow. The domesticated es is of great importance to the natives of Thibet. yak is employed as a beast of burden, but never tillage or draught. It yields a very rich milk and xcellent flesh.

hrough the courtesy of Prof. Gasser of the Alaska ege, I secured a sample of male yak hair from an nal which is kept at the Fairbanks station. The coat also consists of an outer covering of dark vn or black beard hair, and an under coat of brown l hair. Judging by the sample, the down consists ery short and not particularly fine hair, about one in length, varying from 13 to 35 microns. The ation curve is seen from Figure 13. The average 300 fibers is 21.25 microns, equal to quality 64. ause of the strong pigmentation of the fibers, the es are hardly seen, which is proven by Figure 14. number of scales is about 10 per 100 microns. beard hairs are mostly straight and are very dark wn or black. Under the microscope they show no cial difference against any known beard hair. Their gth is about three to four inches. The fineness is n from Figure 13 and fluctuates between 27-85 rons, the average being 46.2 microns. The beard- rs of the yak are also much finer than the musk-ox rdhair, for this reason I assume that the statement n Deputy Minister Cory refers to the outer coat of animal.

Fig. 14. Yak Hair (240 X)

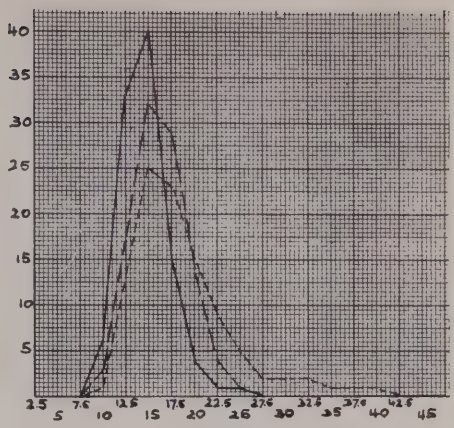



Fig. 15. Width Variation Curves of
———————— Vicuna Wool Hair
— — — — — Cashmere Wool Hair
— — — — — Camel Wool Hair

The wool hairs are not nearly as valuable as the musk-ox wool hair. The hair is spun into ropes and made into coverings for tents by the natives of Thibet, and the soft fur of the hump and withers is woven into a fine strong cloth. The tails, often dyed red are made into chowies or fly-flappers, used in India. In my opinion, one cannot speak here of any great similarity. Therefore, in the following Table II the properties of vicuna, cashmere and camelhair, technically used hairs,

TABLE II

| Woolhair | Musk-Ox White Faced | | Vicuna | Cashmere | Camel (Fine) |
|---|---|---|---|---|---|
| Color | Gray White gray | | Brown | Wh.-gray Brown | Red brown |
| Luster | Good | | Good | Good | Good |
| Handle | Extra soft Silky | | Extra soft Silky | Extra soft Silky | Soft Silky |
| Lengths | 1½–6″ | | ..... | 1¼–3½″ | 1–5″ |
| Bulk | 3–5 | | 2 | 2 | 2½ |
| Waviness | Curly | | Curly | Curly | Curly |
| Scales per 100 Microns | 6 Visible | | 7–9 Poorly visible | 6–7 Clearly visible | 9 Poorly visible |
| Fineness | Alaska | | | | |
| | *Root* | *Middle* | | | |
| Under 15 mic. | 91% | 51% | 79% | 52% | 39% |
| 15–25 mic. | 9% | 47% | 21% | 48% | 52% |
| Over 25 mic. | 0% | 2% | 0% | 0% | 9% |
| Average | 11.4 μ | 15.3 μ | 13.4 μ | 15.0 μ | 17.5 μ |
| Quality English | 140 | 100 | 120 | 100 | 80 |
| Medullated Fibers | None | | Numerous | None | Numerous |
| Beard Hair | | | | | |
| Color | Brown and Black | | Brown | White Br. & Blk. | Brown |
| Length, Inches | 1–16″ | | 8″ | 1½″–5″ | 2–5″ |
| Fineness Average | 100μ | | 75μ | 60μ | 60μ |

Fig. 16. Musk-Ox Wool (240 X)

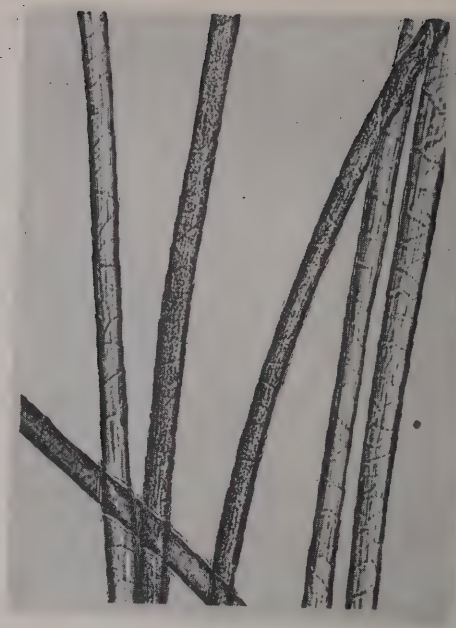


Fig. 17. Cashmere (240 X)

are noted for comparison, at the same time the variation curves of the three are seen from Figure 15, and the microphotographs Figures 16, 17, 18 and 19, show clearly the difference in the structure of each fiber.

From this table and Figures 15-19, it can be seen that the musk-ox wool hair from the back and shoulder parts comes closest to the cashmere wool hair in its microscopic structure and as far as fineness points are concerned, it is even superior. In a blend of these two fibers it will be nearly impossible even with the microscope to separate the fibers for an accurate analy

Unfortunately I have not as yet been successful obtaining a raw sample of vicuna but it is my bel that the musk-ox wool hair, growing on the shoulde of the animal is the finest wool hair which is kno today.

## Workability

The only humans so far, who have made use of t wonderful wool, are the Eskimos and Indians Greenland and Canada. It is used as fur robes a

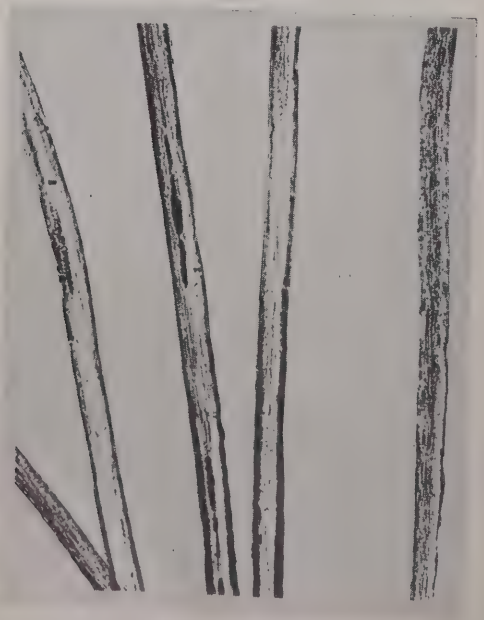


Fig. 18. Vicuna Wool Hair (240 X)

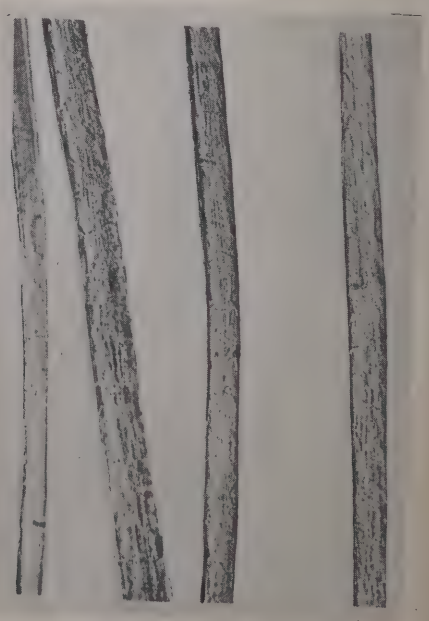


Fig. 19. Camel Wool Hair (240 X)

ling, but no spinning nor weaving is done. The regarding the wool for manufacturing purdivided. V. Stefansson, the father of the cation idea, stated that the development of x herds will represent not only an addition to t industry but also to the wool production.

1 *ovibos** (Latin name for musk-ox) skins were brought south by Stefansson's Canadian Expedition 1913-18 and from a trading station hern Baffin Island, Stefansson had fifty to sixty of wool. Some was worked by hand into socks ttens in the ordinary old-fashioned way. About nds were handed over to Prof. Aldred F. Barker f the Textile Department of Leeds University ade the following tentative statement:

e heat-retaining qualities of *ovibos* wool seem to east as good as the best domestic sheep product. ool will take dye readily. Its soft, native brown resent a very fashionable color and seems, theretuitable, but it can be bleached a pure white inexely by processes already in use. The cloth can ven by machinery used for ordinary wool; no l machinery or invention is necessary for separae long hairs from the wool when such separation ired. For certain purposes it is an advantage to he hair mix with the wool. The hair if separated the wool will be of some value as a by-product. ure wool fabric will have approximately the softof cashmere, and, what many will consider imnt, the cloth will not shrink even when washed in vater and rubbed."

e report of the Royal Commission is less optic:

he value of the wool which constitutes the inner of the musk-ox is, as yet, problematical. In itself wool is of fair quality, but though experiments to end are now in progress, no machinery has so far perfected which will successfully separate it from coarse hair of the outer coat, with which it becomes ed when being shed. The shedding is a gradual ess, the new wool taking the place of the old as is shed, and there is, therefore, grave doubt as to practicability of removing the latter until it has 1 properly replaced by the fresh growth."

n the same report we find a statement from Prof. T. Hornaday, Curator, New York Zoological Soy, as follows:

I do not believe that musk-ox wool ever can be ne a valuable commercial product. I think there is practical way in which the wool can be made avail e in commercial quantities. We once combed the ol completely out of a two-year-old musk-ox at a ne when it had been shed and was ready to work out through the long hair. It is a long and tedious operation, and about one month later that particular musk-ox died of pneumonia. We never again attempted an experiment of that kind."

The decision whether or not a wool fiber or hair is suitable for the manufacturing cannot be made only on the foundation of such insufficient facts. As manufacturing requirements, the British Research Association for the Woolen and Worsted Industries has suggested as preliminary for such investigations the following factors:

1. Staple length
2. Suitable weight of fleece for each particular breed of sheep
3. Crimp
4. Diameter of fiber from specified portions of fleece
5. Evenness
6. Suitable contour of cross section
7. Probable limits of spinning count
8. Texture
9. Color
10. Luster
11. Soundness
12. Suitability for combing or carding
13. Felting and milling properties
14. Average yield of clean wool from the greasy fleece
15. Amount of grease in the fleece
16. Noil yield
17. Chemical constitution, for example, sulphur content, etc.
18. Physical characteristics, elasticity, etc.
19. Dyeing and finishing properties
20. Probable uses to which each type of wool could best be put.

It is obvious that all these characteristics will, if comparison is to be effected, necessarily have to be defined in very precise terms, and suitable standard tests devised so that they may be compared in a proper manner. Coupled with this investigation, information should be secured regarding the various contributive factors during the wool growth, as for example:

1. Geographical location
2. Height above sea level
3. Atmospheric conditions
4. Drought and rainfall, etc.
5. Pasturage, method of feeding, etc.
6. Soil.

* Name preferred by Stefansson **ovis** = sheep, **bos** = cattle, **ovibos** sheep cattle.

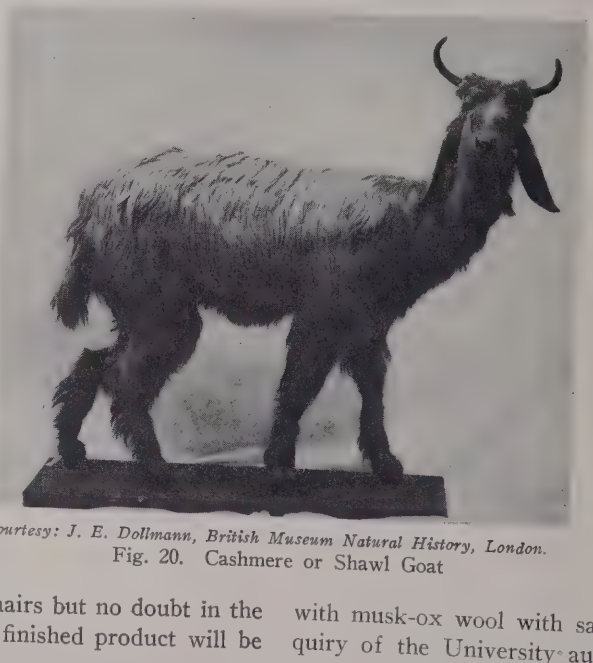
Any other factors concerned with purely local conditions of production should be included.

There is another side, namely, the biological factor, which has to be considered, and the conditions under which breeding takes place should be investigated. A note on the biological aspects of wool research will serve to illustrate the vast field of investigation to be covered before the results of the survey can be considered as complete, or have any semblance of finality.

In my own investigations concerning musk-ox wool I was able to find out the greater part of the necessary characteristics. Notwithstanding, my research regarding this wool is far from complete, I still take the liberty to bring forth the following facts concerning the aforementioned matter:

I am completely in accord with Stefansson. In the example of the cashmere goat the opposition of the foregoing is made possible.

The cashmere goat (see picture Figure 20) has a similar outer coat of beard hairs which becomes mixed with the wool hair when being shed. The regular commercial cashmere wool contains about 30% beardhairs and they are successfully separated during carding and spinning, so that the amount in the finished goods is less than one-half per cent. I cannot see any reason why the same thing should not be possible with musk-ox wool. It will not be as easy because of the greater length of the musk-ox beard hairs but no doubt in the hands of a good spinner, the finished product will be nearly as good as cashmere.



*Courtesy: J. E. Dollmann, British Museum Natural History, London.*
Fig. 20. Cashmere or Shawl Goat

The cashmere goat is subject to the same gradual shedding process. Most of the cashmere wool or pashm is secured by combing the animals, when it loosens from the skin. The time required for this collection is from 8 to 10 days. A considerable amount is picked from the bushes, where the animals have rubbed in an effort to remove the sloughing hair. For this reason I do not see any great disadvantage when the wool has to be collected over a certain length of time. The animal which died of pneumonia after being combed in the Zoological Park in New York is no proof at all that the same animal would have died in the sub-arctic zone. The climatic conditions and the weaker resistance of the animal living in captivity was in my opinion, responsible for its death. In th nection we can say that the collecting of th parallel to the gradual shedding process will pro animal from catching a cold.

I am convinced that the musk-ox wool will a valuable commercial product after domest The amount of usable wool combed from a ca goat is 10-14 ozs. per year and it should be poss get at least 2-3 lbs. from the musk-ox which i to four times larger. A camel (China) gives a lbs. As with the camel's hair it will be poss place different qualities on the market according amount of beardhair present. By being fairly c during the combing of the animals, it should be e secure from the shoulder parts, a product almos from beardhairs, which could obtain a similar pr the market than cashmere or even vicuna.

We will be able to produce from this very fin down, goods whic be equal to the f cashmere shawls ma the inhabitants of mir, or the valuable kets made from v by the Indians of The finest quality c finest dress goods w manufactured by A cans from an Ame product.

In a letter of Au 1930, W. W. Cory, uty Minister of Northwest Territ of Canada, informe that the Textile de ment of the Unive of Leeds, England, ducted some experim with musk-ox wool with satisfactory results. My quiry of the University authorities of Leeds, has to the present remained unanswered.

After the first part of this article was printe September (Vol. III, p. 472) and through the c tesy of Dr. Schwarz, the Editor of the MELLI TEXTILE MONTHLY, presented to Mr. Vilhjalm Stefansson, I had the privilege of meeting the great plorer personally, and through his kindness I secu all the missing information about the experiments the University of Leeds and many more which en me to place my judgment on a much wider basis.

Influenced through the discoveries of Mr. Stefa son regarding the possibilities inherent in the hair wool of the musk-ox A. F. Barker and F. H. D. Atk son carried out preliminary researches on these fib in the University of Leeds during the summer of 19

and 1922 practical experiments were made 40 pounds of musk-ox hair received from on and the work made the basis of a thesis—dy of the Ovibos Fiber from a Textile Stand- y Frank H. D. Atkinson under the supervision A. F. Barker. For this thesis Atkinson re- ie University of Leeds diploma in Textile In- in June 1922. This thesis was never printed, hand-written original was sent, in September Mr. Stefansson and from him it went to the nent of Marine in Ottawa, Canada. The Gov- of Canada intended to publish the entire thesis

from the west side of Hudson Bay to Bank's Land. *Melville Island Musk-Ox—Ovibos Moschatus Melvillensis.* Kovarsik, Melville Island.

*Hudson Bay Musk-Ox—Ovibos Moschatus Niphoecus* (Elliot) Blacker in color, horns are lighter, little white on head. Region to the northwest of Hudson Bay.

*Ward's Musk-Ox or White-faced Musk-Ox—Ovibos Moschatus Wardi* (Hydekker) White space between horns and on face, also generally whitish on sides of head; more white on feet. General color lighter. Eastern Greenland.

*Courtesy Bureau of Biological Survey, Exp. Sta., College, Alaska*

Fig. 22. Musk-Oxen in Feed Yard at Handling Sta. No. 2, College, Alaska

er with the report of the 1913-18 Arctic Expedi- This was never done and so one of the most tant documents about the musk-ox was withheld ine years in the archives of a government office. fact was even unknown to the Department of the ior in Ottawa, which is in charge of the conserving nadian musk-oxen.

on my request Mr. Stefansson demanded that the ment be returned to him, and the thesis was re- d to him in October. This gave me the oppor- y to study in the last minute the most important e for my research work on the musk-ox fibers, to compare Atkinson's results with my own data.

*dian Musk-Ox Hair*

the first place I had to establish that the hairs d in Leeds were from a Canadian species. There known to be four related species of musk-oxen.

*ted Species*

*ommon Musk-Ox.—Ovibos Moschatus Moschatus* mmermann), the typical form. Arctic America

TABLE III

| Wool hair | Musk-Ox White Faced New York 1930 | | Musk-Ox Canada Leeds |
|---|---|---|---|
| Color | Gray White-Gray | | Brown |
| Length | 2" - 5" | | 3" - 3.5" |
| Bulk Scales per 100 microns | 6 visible | | 6 poorly visible* |
| Fineness | Alaska middle | New York | |
| Under 15 microns | 51% | 38% | 48% |
| 15-25 microns | 47% | 59% | 48% |
| Over 25 microns | 2% | 3% | 4% |
| Average | 15.3 microns | 16.53 microns | 16.15 microns |
| Beardhair Color | Brown and Black | | Black |
| Length | 1-16 | | 8-12 |

* Covered by dyestuff pigments.

The fibers dealt with in this study come from the last species.

The main difference which exists in the fibers of the Canadian species and those of the Greenland species is the color of the fine down or wool hair. The under-hair of the first is brown and of the latter gray. The other physical properties are similar to each other which can be seen from Table III.

In Leeds about 15 pounds of 100% musk-ox yarn were produced after the English worsted method. From this yarn 1/20's and 1/10's weaving and hosiery yarns

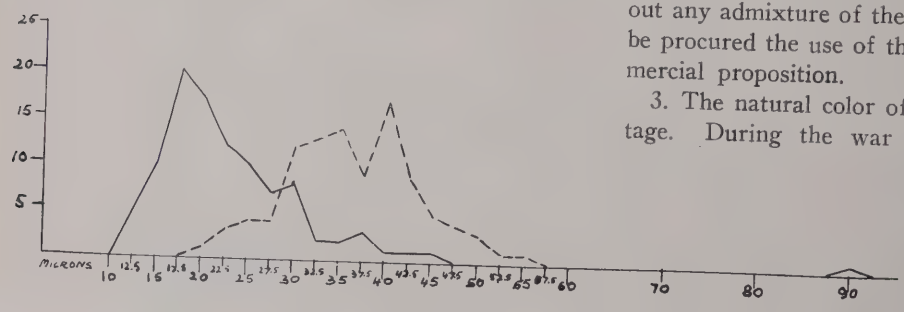



Fig. 21. Width Variation
————Musk-Ox Yarn
— — — — Wensleydale
Yarn Leads

were made through twisting in 2/20's, 3/20's, 2/10's and 3/10's with different turns. The yarn possesses an average amount of strength. The weaving yarn was made into different kinds of goods. One part of the yarn was combined with a yarn containing Yorkshire's

one, because the character and soft handle musk-ox wool were entirely covered by the coar The two curves of the fineness show this fa clearly. (Figure 21.)

After spinning, weaving, and finishing d kinds of goods of musk-ox or *ovibos* hair, A came to the following conclusions:

1. The handle of the fine *ovibos* is of such s that it can be favorably compared with cashm vicuna.

2. If sufficient quantities of *ovibos* under-hai out any admixture of the long coarse outer-hair be procured the use of the fiber would become mercial proposition.

3. The natural color of the under-hair is an tage. During the war natural colors were

prized in that they helped eke out the wool su and also afforded a welcome amelioration of th stuff situation.

4. The most useful results could be procured use of *ovibos* under-hair for hosiery purposes,

*Courtesy Bureau of Biological Survey, Exp. Sta., College, Alaska*

Fig. 23. Musk-Oxen at Biological Survey Exp. Sta., College, Alaska

most typical wool—the Wensleydale—and two pieces were woven. From this cloth three suits were made and one was presented to the King of England, one to Stefansson and one is the property of Prof. Barker.

In my opinion this combination of the fine musk-ox wool with the coarse English wool was an unfortunate

gloves, scarves, etc., provided there were no long h present.

5. If cloths were made they would be more ad able as warm linings to winter waistcoats, etc., t for suitings.

6. Warm, soft and full handling rugs could be m

vantage from the under-hair. The bursting of
ı by attempts at milling would bring about the
results.

ıe non-milling property of the under-hair is an
ge because the air-retaining qualities of a fabric
ctically consistent with its heat-retaining prop-

ıe difficulty of obtaining the fine under-hair
ɔuld be great.
ıe only method would be that of combing it out
nonth of June after it has loosened at the roots.*
The coarse outer-hair of the *ovibos* could be
in the same manner as horse hair for uphol-
tc.

through the use of this extract from Mr.
on's thesis my article may be considered as com-
I am glad that in the main points I came to the
conclusions and confirmed the research of Prof.
and Atkinson without being influenced by their
gs. Upon the various points I wish to take the
of making the following remarks:

3. In my opinion the gray-white colored
-hair of the Greenland musk-ox today, is of more
than the brown colored hair of the Canadian
ls, because a much greater variation of shade is
ɔle through dyeing with different colors. P. G.
ıgton was fortunate in selecting the white-faced
-ox for domestication in Alaska.

5. The fine hair, as vicuna, cashmere and
lhair, never were really suitable for suitings, they
nore adaptable for the manufacturing of dress

ɔds, made from woolen yarns, and as the musk-ox
ır is a similar fiber this applies to it also. When I
alyzed the yarn spun in Leeds (sample obtained from
suit of Mr. Stefansson) I realized the difficulties
ey had even to spin 1/20 worsted. In the following
ıble IV we have the result of the fineness analysis
d for comparison an analysis of a regular camelhair
ɔol yarn and a carded sample of musk-ox wool from

* Dr. W. T. Hornaday, Director of the New York Zoological Park, nks that this would be a serious undertaking as it would involve pturing the animal, throwing it and holding it down. Any **ovibos** us treated would, he says, be a fit subject for pneumonia, as they n easily contract that disease during any period of cold spring rain.

the New York Zoological Garden, and a carded sample of musk-ox wool from Alaska yield Summer 1931.

The presence of over 10% of fibers coarser than 30 microns and 1% even coarser than 80 microns reduces the spinning quality of a fiber enormously.

To 9. To procure a valuable wool hair from the musk-ox the combing out of the animal has to be done very carefully, and the hair classified on account of the beardhair present.

That this is possible is proven by the figures for the carded Alaska musk-ox wool in Table IV, which shows that only 3% of the hairs are over 30 microns and none over 40 microns. So the spinning properties of this wool are at least as good as that of fine camel hair.

For this Alaska sample I am indebted to W. B. Bell. The yield of this 1 lb. sample obtained from him was 84% which proves the correctness of my estimate on page 646 of the November issue.* The fat content was 4.3% which is about the same as for raw cashmere.

This new-coming musk-ox industry will be the source of a better life for the white man, Eskimo and Indian of the Arctic. Let us verify the words of Irving McK. Reed, of Fairbanks, Alaska, a member of the Alaska Game Commission:

"Domestication of musk-oxen is one of the greatest constructive efforts in behalf of the Territory of Alaska (also of the whole Arctic) insuring a firmer foundation for a white population and our American civilization which must have some kind of agriculture as its foundation and cannot be permanently based on such ephemeral industries as mining and trapping. It will not only benefit this generation but untold future generations."

Mr. Reed passed through the wonderful building-up of the reindeer industry in Alaska. The reindeers have increased from 1280 heads imported into Alaska from 1892 to 1902, to nearly a million heads at the present time. Why cannot the musk-ox industry have the same future?

The United States Government and Canada are not the only ones who believe in the future of the musk-ox.

* Page 7 of this Reprint.

TABLE IV

| ·ons | 7.5 | 10 | 12.5 | 15 | 17.5 | 20 | 22.5 | 25 | 27.5 | 30 | 32.5 | 35 | 37.5 | 40 | 42.5 | 45 | 47.5 | 50 | 85 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| k-Ox arn eeds | .. | .. | 5 | 10 | 20 | 17 | 12 | 10 | 7 | 8 | 2 | 2 | 3 | 1 | 1 | 1 | | | 1 |
| sk-Ox arded [. Y. | .. | 3 | 10 | 24 | 27 | 15 | 6 | 3 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | |
| nelhair 'arn | .. | 1 | 11 | 30 | 17 | 14 | 9 | 3 | 3 | 2 | 1 | 1 | | | | | | | |
| sk-Ox Carded Alaska | 2 | 21 | 26 | 18 | 11 | 9 | 4 | 3 | 2 | 2 | 1 | 1 | 1 | | | | | | |

About two years ago the government of Norway started a similar experiment with the animal in Spitzbergen, and in 1930 a private organization made a breeding trial in Iceland which did not succeed, as six of the seven animals caught a disease from the sheep.*

In closing I wish to express special thanks to the officials of the Department of the Interior, Canada, who served under the Administrations of 1930 and 1931, for all the literature received, to Dr. W. Reid Blair, Director of the New York Zoological Garden, and to L. I. Palmer, Senior Biologist for the different samples of musk-ox hair, and especially to the man whose name will always be mentioned in connection with the musk-ox, Vilhjalmur Stefansson, the father of the domestication idea.** I shall never forget the great confidence he placed in me when he allowed me to study his confidential records in the library of his New York residence.

Only through his tenaciousness and perse in sticking to his idea are we indebted to t that domestication of the musk-ox is well way in Alaska. This is proven by the eviden sented by the last two pictures Figures 22 and am indebted to Mr. W. B. Bell, in charge of th sion of Biological Investigations, of the United Department of Agriculture for the two photo and I wish to thank him for the interest shown study.

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* A new trial was started with seven Musk-ox calves in November, 1930; of these, five were owned by the government of Iceland. In October, 1931, the five calves owned by the government were well off and had more than doubled their weight from January to October, 1931.

Jan. 14. Average Weight, 119 lbs.
Sept. 28. Average Weight, 251 lbs.

One is inclined to believe that the experiment will be a success. (The above excerpt was taken from an article on the Sheepcow by Arsaell Arnason, published in a volume on fur farming, Reyjavik, 1931.)

** Mr. Stefansson told me when I saw him in February that he was not the first man who had the idea of the domestication of the musk-ox; the credit should go to a Frenchman, Jérémiés, who, in 1708, brought to France from Canada some musk-ox wool, and stockings were made from this wool. He describes it in his book, "Jérémiés' Account—Hudson Strait Bay," which was printed in 1720 in Amsterdam, French Edition; it was translated into English in 1926 by R. Douglas and J. N. Wallace of Ottawa. He said that the wool was much finer than silk and that it would be worthwhile to domesticate the animal because of this fine wool.

There appears in a book, written by a Mr. H. Hughes, and entitled "Arctic Zoology" (published in London in 1784), a very good description of the musk-ox with a wonderful picture of the animal, and the writer makes the following statement in regards to the wool:

"The ash-colored wool is most exquisitely fine, superior, I think, to any I have ever seen, and it might be very useful in manufacturing if sufficient quantities were available."

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